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the purpose at Arequipa. Further observation is necessary before definitive results can be given, but for the preceding variables provisional periods and median magnitudes have been obtained.

The numbers, except the last, are those published by Miss Leavitt. Colons indicate periods not well determined. For stars marked with an asterisk a multiple of the period given above satisfies the observations nearly or quite as well.

The light curves are in all cases of the typical cluster form. From the plates now available, the elements of variation could not be determined for some of the other faint stars, but for none do the observations demand a long period.

The median magnitudes are derived from published values of maximum and minimum, except that for No. 1741 which is a revised unpublished value derived by Miss Leavitt, and that for No. 3610—a hitherto unannounced variable. The medians are based on a provisional and apparently homogeneous system of magnitudes for the comparison stars. The standardization of these magnitudes is under way and will permit a new evaluation of the medians for the variable stars and a redetermination of the distance of the Small Magellanic Cloud.

The mean of the thirteen periods is 15.4 hours. The mean of the thirteen median magnitudes is 16.13 ± 0.05, in close agreement with the median magnitude, 16.2, predicted from the extended period-luminosity curve for variables of this period. We are led to the conclusion, even after making ample allowance for the provisional nature of the magnitude scale and for the uncertainties that affect some of the periods, that cluster type variables are giant stars in the Small Magellanic Cloud, as previously found for certain globular clusters. Naturally we infer that they are giants stars wherever they occur.

THE VITAL INDEX OF THE POPULATION OF ENGLAND AND WALES, 1838–1920[1]

BY RAYMOND PEARL AND MAGDALEN H. BURGER

DEPARTMENT OF BIOMETRY AND VITAL STATISTICS, JOHNS HOPKINS UNIVERSITY

Communicated, February 14, 1922

The senior author[2] has suggested the term "vital index" as a convenient designation of the function

$$V = \frac{100\ Births}{Deaths}$$

which measures more effectively than any other demographic function yet devised the essential biological fitness of a population, in the sense of organic evolution. For a population V is the direct measure of survival value. If $V > 100$ the population is not only surviving but growing, whereas if $V < 100$ the population is starting on the road to elimination, and must eventually disappear unless the vital index gets above 100. A detailed presentation of the facts regarding the vital index of certain elements of the American population has lately been published.[3]

In examining the effect of the Great War upon the growth of population one cannot fail to be impressed by the fact that the return of the birth/death ratio (vital index) to a normal or even super-normal value after the marked dislocation produced by the war, and at its end the superimposed influenza pandemic, was extraordinarily rapid. Indeed the senior author[4] was led to remark, after examining the matter in the chief belligerent countries, that "Altogether, these examples, which include the effects of the most destructive war known to modern man, and the most devastating epidemic

TABLE 1

RATIO V, OF 100 BIRTHS TO DEATHS IN ENGLAND AND WALES IN EACH QUARTER OF THE YEARS 1838 TO 1920, INCLUSIVE

	QUARTERS ENDED			
YEAR	MAR.	JUNE	SEPT.	DEC.
1838	116	134	157	140
1839	138	146	157	141
1840	134	143	148	135
1841	135	151	164	150
1842	141	155	150	148
1843	144	150	167	150
1844	142	160	163	143
1845	137	153	177	163
1846	162	166	136	128
1847	122	130	136	123
1848	116	150	160	144
1849	145	150	100	139
1850	147	168	171	159
1851	149	160	165	150
1852	152	158	151	152
1853	137	147	160	140
1854	144	168	136	133
1855	123	155	177	153
1856	164	173	173	164
1857	157	170	160	146
1858	136	158	160	133
1859	144	166	161	155
1860	149	157	190	158
1861	143	172	170	159
1862	149	173	187	150
1863	145	160	154	155
1864	135	161	161	144
1865	138	167	160	148
1866	142	150	153	158
1867	145	178	176	158
1868	166	184	147	160
1869	153	159	166	149
1870	143	168	155	151
1871	151	167	159	144
1872	155	173	170	176
1873	163	174	178	160
1874	157	176	169	150
1875	132	164	174	159
1976	162	179	180	177
1877	171	170	195	177
1878	158	177	172	155
1879	145	167	210	160
1780	152	186	167	165
1881	163	186	196	177
1882	159	182	186	163
1883	158	171	189	167
1884	170	181	167	165
1885	157	168	191	173
1886	147	184	179	168
1887	153	176	178	163
1888	149	179	199	169
1889	158	183	180	165
1890	136	171	180	139
1891	145	139	192	156
1892	120	176	197	168
1893	160	177	160	147
1894	155	186	201	180
1895	141	179	174	161
1896	163	185	181	168
1897	164	179	169	170
1898	154	183	166	169
1899	157	182	151	152
1900	132	166	175	167
1901	158	182	169	167
1902	153	179	209	168
1903	170	195	207	169
1904	157	192	178	165
1905	160	192	195	172
1906	169	189	181	166
1907	143	187	216	161
1908	153	201	208	170
1909	143	189	218	172
1910	163	203	218	168
1911	156	188	158	169
1912	154	188	216	170
1913	148	187	199	172
1914	149	182	197	159
1915	125	154	180	134
1916	136	165	193	134
1917	109	136	172	136
1918	118	144	147	67
1919	75	137	197	195
1920	197	208	245	180

TABLE 2

GROUPED DATA FOR VITAL INDEX AND CRUDE BIRTH RATE

PERIOD	BIRTH	DEATHS	100 BIRTHS / DEATHS	GENERAL BIRTH RATE PER 1000
1838–1839	956,361	681,744	140.28	31.0
1840–1844	2,600,288	1,756,431	148.04	32.2
1845–1849	2,797,329	2,003,657	139.61	32.6
1850–1854	3,080,095	2,030,528	151.69	33.9
1855–1859	3,300,929	2,126,461	155.23	34.3
1860–1864	3,560,830	2,263,769	157.30	34.9
1865–1869	3,830,527	2,438,121	157.11	35.3
1870–1874	4,100,856	2,541,625	161.35	35.5
1875–1879	4,399,070	2,623,391	167.69	35.6
1880–1884	4,451,771	2,591,038	171.81	33.8
1885–1889	4,450,173	2,620,108	169.85	32.0
1890–1894	4,486,912	2,778,642	161.48	30.5
1895–1899	4,611,116	2,771,151	166.40	29.6
1900–1904	4,691,038	2,739,365	171.25	28.5
1905–1909	4,637,271	2,613,992	177.40	26.7
1910–1914	4,411,823	2,519,713	175.09	24.2
1915–1919	3,623,894	2,685,456	134.95	20.8
1920	957,994	466,213	205.48	25.5

since the Middle Ages, furnish a substantial demonstration of the fact that population growth is a highly self-regulated biological phenomenon. Those persons who see in war and pestilence any absolute solution of the world problem of population, as postulated by Malthus, are optimists indeed. As a matter of fact, all history definitely tells us, and recent history fairly shouts in its emphasis, that such events make the merest ephemeral flicker in the steady onward march of population growth."

In view of the fact that this function V has so quickly returned to normal, or approximately normal, values after the recent disturbances it is a matter of considerable interest and significance to the student of problems of public health in the broad sense, of population growth, and of human ecology, to see how precisely the self-regulatory mechanism of populations operates over long periods of time. To this end we have examined all the existing continuous statistics of England and Wales, and desire to present the results in this paper.

Table I gives the vital index (100 births/deaths) for the population of England and Wales, in each quarters of the years 1838 to 1920 inclusive. The data from which the computations were made were taken from official sources.[5]

The immediately striking feature of this table is the extreme constancy of the values as one runs down the columns. In order to appreciate this fact fully, however, it is necessary to resort to graphical presentation. As the data of table I are too detailed to make such an examination of the trend feasible within the space of a single printed page, the data have been combined in quinquennial periods in table 2. In this table are given, for each 5 year period, the total births, total deaths, vital index, and crude birth rate. The latter figures have been calculated directly from the birth and population figures and differ slightly (but in no wise significantly) from the crude birth rates given in Annual Reports of the Registrar-General, chiefly because of the fact that we have used a different quinquennial grouping.

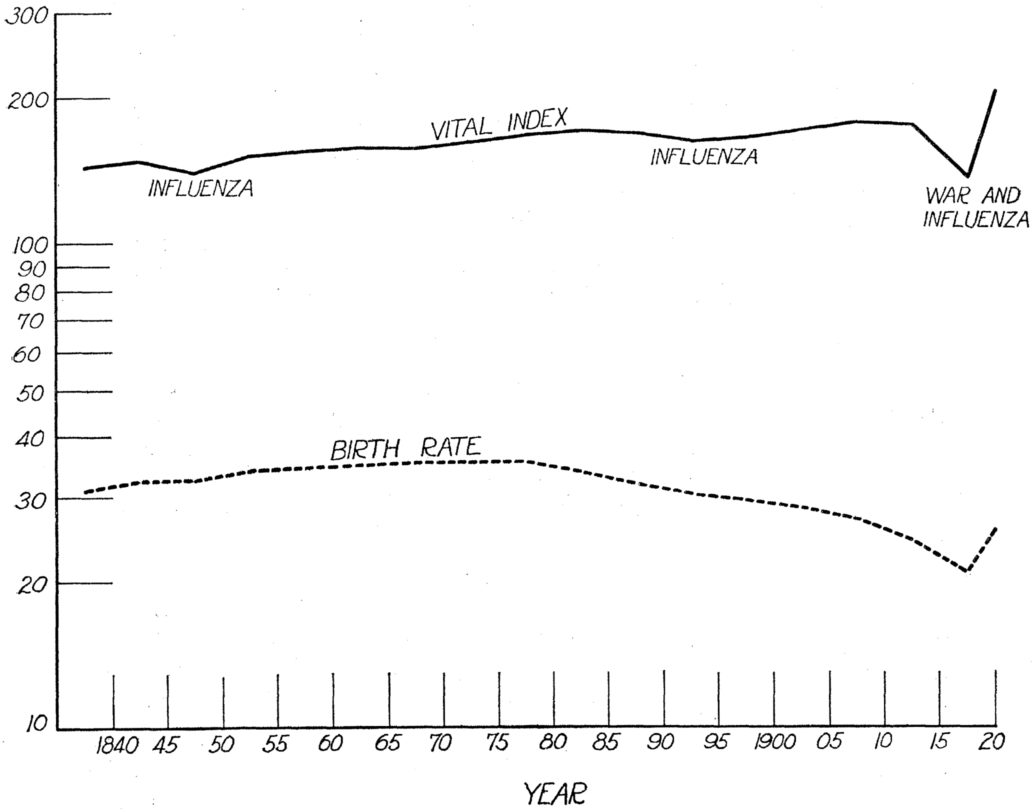

FIG. 1

Trend of vital index (100 births/deaths) and crude birth rate in England and Wales, 1838–1920, inclusive

The vital index and birth rate data from table 2 are shown graphically in figure 1.

The diagram is plotted on an arithlog grid, in order that the slopes of the lines may be strictly comparable.[6]

It is at once apparent that *the ratio of births to deaths in England and Wales had a slow but extremely even and steady increase from 1838 to 1914.* This steady progress was interrupted to a degree sufficient to be apparent upon only two occasions during the three quarters of a century. These were in 1847–1849 and 1890–1892. These fluctuations, which only slightly affected the even upward trend of the curve were due to the influenza pandemics of 1847–8 and 1890–1891. The broad result is perfectly clear and outstanding. The population of England and Wales is today biologically fitter and possessed of greater purely biological survival value as a whole population than it was three quarters of a century ago. Whether it is a mentally, morally or anthropmetrically fitter population does not now concern us. We are dealing at the moment solely with the fact that, taking the people of England and Wales as a whole, slightly over 2 babies were born for every death in a year in 1920, as against 1.4 babies per death in a year in 1838–1839. The question of a differential fertility among different social classes we shall discuss farther on in the paper.

Now this result, which is beyond any question a fact, will strike anyone informed as to the sociological and eugenical literature of the last two decades as curiously at variance with the pessimistic tenor of that literature, taken as a whole. It has been pronounced from high places that the general trend of the British people was biologically downwards, that they were in fact becoming biologically dangerously near to a decadent race. Abundant quotations in support of this contention could be cited, were space available and were it necessary. This gloomy view has had its foundation solely upon the fact that, since the quinquennium 1875–1880, the birth rate in England and Wales has been falling rather rapidly, as is clearly shown in figure 1. This fact has been brought out by Elderton[7] in great detail.

But from a purely biological view-point, what matters a falling birth rate if the death rate falls even more rapidly, so that the net survivorship at any instant of time is constantly getting higher? To this it will, of course, be answered at once by those who view with alarm the declining birth rate that the real crux of the matter is in the differential change in fertility. Nowadays the "best" people do not produce their due share of progeny, while the "worse" people over-produce. If one accepts the man-made definitions of "best" and "worst" this is plainly true for some civilizations at least. In the American population, however, as one of us[3] has recently shown, the element probably least desirable racially, the negro, has the lowest survival value as a group (vital index generally less than 100). But is old Dame Nature ever really interested in any test of "best" and "worst" *except survival?* There is no evidence as yet that she is. Measured by this test the population as a whole of England and Wales is today biologically more vigorous than it was in 1838. This is a plain *fact.* Whether this fact is, sociologically or eugenically considered, a bad thing or a good thing, is something more than a purely biological problem, and as such we are content to leave it to the discussion of others.

What seems to us of considerable interest biologically, is the extraordinary perfection, demonstrated in the figures here presented, of the self-regulation of population growth. Disturbances of the course of the birth rate have been compensated for, in the population and period under review, with the greatest nicety. It will be of interest to examine the facts for other populations, and this we hope later to do.

[1] Papers from the Department of Biometry and Vital Statistics, School of Hygiene and Public Health, Johns Hopkins University, No. 50.

[2] R. Pearl, "The Effect of the War on the Chief Factors of Population Change," *Science* (N. S.), **51,** 1920 (553–556).

[3] Pearl, "The Vitality of the Peoples of America," *Amer. J. Hyg.*, **1,** 1921, pp. 592–674.

[4] Pearl, "A Further Note on War and Population," *Science* (N. S.), **53,** 1921, pp. 120–121.

[5] *Quarterly Return of Marriages, Births, and Deaths Registered in England and Wales, etc.* Published by Authority of the Registrar-General. London. H. M. Stationery Office. *Passim.* Also corresponding Weekly Return, and Annual Reports.

[6] "For a Discussion of the Significance and Advantages of Plotting Trend Lines on a Logarithmic Scale," cf. Fisher, I. "The 'ratio' Chart for Plotting Statistics," *Q. P. Am. Stat. Ass.*, **15,** 1917, pp. 577–601, and Field, J. A., "Some Advantages of the Logarithmic Scale in Statistical Diagrams," *J. Pol. Econ.*, **25,** 1917, pp. 805–841.

[7] E. M. Elderton, "Report on the English Birth Rate. Part I. England North of the Humber." *Eugenics Lab. Mem.*, **19** and **20,** Cambridge Univ. Press, 1914, pp. viii and 246.

SEASONAL FLUCTUATIONS OF THE VITAL INDEX OF A POPULATION[1]

By Raymond Pearl

Department of Biometry and Vital Statistics, Johns Hopkins University

Communicated, February 14, 1922

In earlier papers the writer[2] has discussed various aspects of the birth-death ratio, or vital index of a population, including age and sex specific vital indices, racial and secular fluctuations, etc. Table 1 of the preceding paper by Pearl and Burger[3] gives the necessary data for finding, for one population, that of England and Wales, the course of the seasonal fluctuation of this important demographic constant. It is the purpose of this note to set forth biometrically the facts on this point, from the basic data mentioned.

Table 1 gives the frequency distributions for variation in the value of the vital index of the population of England and Wales in each of the four quarters of the year, ending, respectively, on March 31, June 30, September 30, and December 31, during the years 1838 to 1920, inclusive. The source of the data is given in Pearl and Burger already cited.

The significant biometric constants from table 1 are presented in table 2. It is apparent that there are a few highly aberrant observations in